Cooperative Research CEntre for Sustainable Rice Production
Salinity Research Workshop Report

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Introduction

The CRC for Sustainable Rice Production Management Committee questioned whether the CRC Strategic Plan sufficiently addressed the problem of salinity, (and whether the current portfolio of salinity-related research projects is sufficient in scope or extent to address the perceived major research needs??????). Therefore a workshop was e identified salinity related research as a deficiency in its Strategic Plan and decided to conduct a workshop. The purpose was conducted to determine whether there are significant areas of important salinity research,, which are not already being addressed by the programs in placeexisting projects within the CRC or by other research groups.

To this end aThe workshop was held on 25 November 1999, at the CSIRO, CLW, Griffith, NSW. A list of participants is shown at Table 1. The facilitator was Mr Lloyd Kingham, of NSW Agriculture,Wagga Wagga.

Salinity research covers a huge range of topics. To bring structure to the workshop six dimensions of salinity research were identified, and these were treated separately. The six dimensions are :

1. Site Specific Salinity Research.
2. Spatial Distribution Issues of Salinity
3. Off-Site Effects of Salinity
4. Effect of Management and Practices
5. Remedial Measures
6. Economics and Optimisation Issues.

Discussion Process

For each topic an experienced researcher was invited to prepare 2-3 pages of notes and to briefly present to these notes at the workshop to provide an initial framework in which to start discussions. The notes aimed at theto identifying the major issues where gaps for research are perceived to exist. The workshop discussions focussed primarily on these areas although other issues did arise. Most time at the workshop was devoted to discussing these and other issues that arose. Discussion was facilitated towards the finding of consensus regarding research priorities, keeping in mind the size of the perceived lack of knowledge gap, its importance on the quest tofor developing practical and useful solutions to the salinity problem, and the capacity of research to fill this gapachievability of the research needed to fill the gap.

Appendix 1 provides the notes prepared by the discussion starters. The text below is a description of the main discussion points. It is assumed that the reader has perused the notes of Appendix 1. The final section of this Workshop report gives an overall assessment of the workshop, followed by recommendations.

Topic 1: Site Specific Research

Dr Wayne Meyer, of CLW, CSIRO, Adelaide, used the DESTINY model as a framework for discussion and pointed out that whilst a lot is already known, there are major uncertainties in several areas as described in Appendix 1. Some factors are extremely difficult to capture in models. The list of potential research issues resulting were:

1. Study of Runoff / Infiltration separation of applied water at ground surface.
2. Relative rates of moisture flow in soil matrix and macro pores – effect on leaching
3. Effect of soil chemistry and on soil structure onand water movement
4. Solute and soil interaction, effect of on salt transport.
5. How exactly does salt affect plant physiological processes
6. Effect of varyiableing soil salt concentrations with depth in root zone on plant growth
7. Day to day effect of soil salt concentration on production potential.

Some workshop participants wondered whether some of these items are actually researchable. Many factors inevitably have to be entered as empirical relations in models, and this could mean models are inappropriate tools for that type of research. Whilst the complexity of the processes and spatial variation may be such that extra knowledge may not contribute a lot to the planning of solutions or remedial measures, extra research efforts in some of these areas would be useful to increase our basic understanding.

The majority of the meeting found that the effect of soil chemistry on soil permeability and soil water movement are the issues most worthy of research. It was pointed out, however, that the first three issues listed really go together, ie it also affects infiltration and matrix pore flow.

The meeting also found that more knowledge is required of the salinity effect on plant growth. This effect is usually represented by the Maas/Hoffman yield response lines. However, it is not known well, if at all, how plants react to salinity variation in the root zone, or how day to day variation may be best represented in a model such as DESTINY. Many workshop participants therefore showed support for doing more work on research issues 6 and 7, which wereare were considered to be linked.

Less support was shown for carrying out more research on the effect of salts on plant physiological processes, or the rate of movement of different cations and anions in soil solutes, relative to the rate of soil water movement.

Topic 2: Spatial Distribution Issues

Dr Shahbaz Khan, of CLW, CSIRO, Griffith, gave an introduction, and a list of projects currently being undertaken. The current research is already addressing some important matters. Appendix 1 provides the notes. The list of research issues identified by the workshop for discussion was as follows:

1. Soil salinity monitoring using remote sensing
2. Correlation of EM survey results with soil data
3. Effect of conjunctive use on spatial distribution of salinity
4. Predicting soil salinity over time based on hydrological models including LWMP options effects
5. Separating climate and management effects in performance monitoring.
6. Effect of hydraulic loading variation on soil salinity risk.
7. Risk based salinity estimation
8. Frequent (e.g. Mmonthly) soil salinity monitoring sites

The workshop formed a view that issues 4 and 5 above were already dealt with, or were being considered by current research projects. It is noted however, that whilst issue 4 has been the subject of a recent project, its conclusions resulted in many concerns regarding the reliability of averaged data, methods and estimates. Estimates are unlikely to have meaning unless they are calibrated against field results. Whilst actual field data were used for the salinity predictions, mMore work in this areamay appears therefore be to be justified to increase confidence in their validity, beyond that currently planned, particularly in the areas of ??????????????.

Regional models were seen as being useful for identifying potential problem areas, and these areas could then be focussed on in terms of monitoring and modelling at finer resolution.

It was pointed out thatThe lack of spatial soil salinity data are is a major handicap for the verification of future models. Salinity data currently collected by Murrumbidgee and Coleambally Irrigation provide statistical distributions, not sufficient for this purpose. Such data is are considered sufficient to get an overview of the extent of the problem, and which sub-districts in a region are affected the most, but it does not provide a map of where exactly the problems are. by Murrumbidgee and Coleambally Irrigation, but not by Murray Irrigation Limited, who which has adopted a GIS to assist with its natural resource management, ?????????-based approach in conjunction with salinity monitoring???????????????. The desire was expressed the view that salinity surveys should explicitly tell where the problem is. Consequently, the pursuit of finding suitable methods for soil salinity monitoring using for instance remote sensing received a lot of support (issue 1). However, the question was raised whether a suitable and reliable low cost method based on the remote sensing concept in fact can be developed ([1]). It is also reasonable to raise the question It may be better to find a technique whether the desired refinement desired can be justified in terms of costs for surveying large areas, hence the importance of predicting the proximity of likely problem areass and then focussing resources on these areas ([2]).

A low cost statistical distribution survey will indicate whether or not a significant proportion of land in a sub-district has a high salinity. If there is not, more knowledge is not required – but this doesn't tell you if there is a potential problem!!!!!!. If there is, then it is likely that local knowledge, EM surveys for whole farm planning, and farmers feedback will provide the knowledge of where the problems occur. More detailed surveys can be postponed until such time.

It was also queried whether whether or not too much effort was going into regional ground water modelling efforts, which use large cell sizes, and consequently have scaling problems, and problems associated for instance with the use of averages for cells. Perhaps the alternative of using a more local scale of one or two farms (sounds like a pretty large scale to me) should get priority. It was agreed that this aspect should be pursued, perhaps as part of the existing project on rice hydraulic loading (also issue 6).

The meeting also found strongly in favour of putting effortThe highest priority issue identified was research into risk based salinity estimation (issue 7), whereby a number of parameters in the landscape are considered, and weighted for an overall risk index. . This reflects a desire to use more simple approaches to identify potential problem areas, rather than developing the complex models, which have often disappointed in the past. However, a note of warning was expressed voiced by one delegate. He recalled a poor experience with an example of this approach, in which the results really were meaningless.

The concept of carrying out monthly monitoring at a number of sites for salinity changes under a range of cropping regimes and soils was considered to be important in order to get back up data for modelling purposes. The meeting agreed that a project of this kind wondered whetherwould not be this is a research project in itself, it would be, or just monitoring as part of a larger modelling project. It may be noted that the three yearly salinity surveys presently carried out by Murrumbidgee Irrigation and Coleambally Irrigation are in fact snap shots in time, and interpretation of variation between years has been an issue. The process of interpretation would be greatly facilitated by linking it to seasonal and annual variation based on these data. rRecommendations to do routine monitoring of this nature have already have been made to the two irrigation companies.Murrumbidgee Irrigation.

It was agreed that issue 3 in this topic should be considered as part of Topic 5 (Remedial Measures).

Topic 3: Off-Site Effects

Dr Glen Walker, of CSIRO, CLW, Adelaide, provided the overview. He emphasised that the control of off-site effects really is within the irrigation areas. Also, the off-site effect may be another location within the same irrigation area.. There is a great need for better predictive methods to estimate salt loads. There are a range of environmental and resource use issues, which actually are the off-site effects – see Appendix 1. Following some discussion the following potential research issues were identified:

1. Level of salt export likely to occur from each irrigated area.

· Is there a need for salt export?

· How much is the minimum need?

· Develop effective predictive models to assess this need for various scenarios and conditions.

2. Management of discharge processes including disposal in IA's (also Topic 5, item5)

3. Study of environmental effects of salt export.

· Effects on wetlands

· Salt intrusion to streams

· Waterlogging effects

· Turbidity effects

4. Impact on ground water systems within and adjacent to irrigation areas.

The off-site impacts in a broader sense should include the effects of for instance water transfers, which reduce hydraulic loading in some areas and increase it in others. There would be a shift in possible downstream consequences. A whole of region water quality approach is needed. An example project considering this and this is being considered for anis an MDBC sponsored project in northern Victoria.

Saline ground water flow may potentially pollute deeper aquifers and affect ground water supply in areas inside and adjacent to outside the irrigation areas. This issue recognised in is also a potential issue, however it was mentioned that current LWMPs of irrigated sareas of NSW. have already considered this effect Not irrigated areas are at most risk, but apart from best management practices to reduce accessions in irrigated areas there are few solutions to reduce the impacts..

A philosophical question arose as to whether all salt export should be banned, or whether it is accepted that a minimum amount of salt export is inevitable. Sustainable management has a target to keep the root zone free of salt. Leached Ssalts in leaching may become part of the ground water system, or salts may be partially discharged via run- off and other drainage. Is a zero discharge feasible?

The workshop strongly supported the idea that research is needed on the minimum salt load discharge, which is required to achieve sustainability. Predictive modelling tools to this effect should be developed. Such research should be conducted in the context of the economic and environmental feasibility of engineering solutions which allow the retention of salts within the irrigation area itself (eg. the CSIRO Evaporation Basin project).

Within irrigation areas salt loads in discharge need to be managed well, and the off-site impacts assessed. Research related to related worksthis are mostly within the realm of Topic 5.

The possibility ofbilityleof effects on wetlands or streams, or water quality issues was recognised, but did not receive a lot of support from the meeting in terms of research priority. Perhaps there was not enough representation at the workshop from this area of research. It may be noted that t The MDBC Salinity and Drainage Strategy deals with annual and monthly salt loads and accounting thereof, but it does not specify EC limits at various points of the Murray Darling River system. Natural increases in salt loads from pre 1988 existing drains may not be managed by dilution flows or other options. Consequently it is probable that from time to time and at certain locations environmental limits for salinity will be exceeded. may have resulted in acceptable bounds, or perhaps there was not enough representation at the workshop from this area of research.

Future impacts from the dry land salinity areas on irrigation areas are of considerable concern. If the predictions of the recent MDBC Salinity Audit are correct, some irrigation areas would go out of production. Irrigation areas in the Murrumbidgee and Murray Valleys would be severely affected if irrigation water salinity increases by over 50%. Associated research issues were not further canvassed at this workshop because there is still uncertainty regarding the estimates.

Topic 4: Effect of Management and Practices

Mr Geoff Beecher, of NSW Agriculture, Yanco Agricultural Institute, introduced the wide range of topics under this banner, see Appendix 1. The meeting identified the following list of possible research issues for which there may be a gap in knowledge not yet being addressed:

1. Study to improve rice suitability criteria
2. Irrigation methods and scheduling research to reduce salinity risk
3. Develop effective soil treatment options
4. Effect of farming systems and rotations on salinity (eg benefit/costs of rice rotations).
5. Establishing inventories of soil salinity extent and trends (also Topic 2, item 1)
6. Research into institutional measures to reduce salinity

The effect of farming systems and rotations on salinity (issue 4) was considered to need further investigations . The role of crop rotations and rice hydraulic loading on accessions and its distribution are important. The volume of accessions generated needs to be dissipated in the non rice areas each year. More needs to be known what these volumes are for individual fields, so that we can then make better judgement and apply better management. This could be partially addressed by Topic 2, Issue 6, but any assessment at present would be indirect.

The possibility of devoting certain areas to rice and other areas for other crops was discussed, but most participants felt rotations are necessary to maintain viability. Land not irrigated at all is at most risk – “If you don’t use it, you will loose it”.

The discussion on soil treatment (issue 3) found the view that the soil compaction treatment to reduce permeability is not very supportable. The consensus appeared to be that small areas within areas otherwise suitable for rice may be treated, but larger areas should be devoted to the development of other, higher value, crops. Rice soils should be treated to make them more suitable for rice. Soil compaction should not be used to convert non-rice soils to rice soils. It was also concluded that in respect of puddling (an effective technique), a lot of considerable research has already been carried out, and the problem is implementation the level of adoption stage, not research.

Whilst the development of rice soil suitability criteria has received consideravle attention in the past, iIt was felt that some more work some more work (beyond what is currently being done????????) on rice soil suitability criteria is justified. New criteria should be linked to an acceptable (accession) flow-through (the profile) rate.

There was some support for including institutional measures such as allocation aspects and water pricing as research issues. The UNE has a special unit considering these aspects. Perhaps for that reason, However, ththe majority of workshop participants did not show support to give this option priority for the CRC, compared to issues 4 and 1.

Topic 5: Remedial Measures

Dr Evan Christen, of CLW, CSIRO, Griffith, outlined this topic, highlighting that shallower drains produce less salt, and that conjunctive use aspects require more attention, building on the experience in Victoria. See Appendix 1. The research issues identified were:

1. Relative merit of land retirement balanced with agronomic controls (rice suppresses salt)
2. Controlled volumes of drainage to reduce salt loads.
3. Development of more effective, shallow, horizontal drainage systems
4. Issues related to shallow ground water pumping for salinity control
5. Disposal and reuse at farm, community and regional scale.
6. Reclamation of sodic / saline soils by biological and chemical means.

Land retirement (issue 1) really is a fall back position, forced upon the community if other methods fail, or are too expensive. It was also felt that some priority attention needs to be given to the issue matter of achieving land getting reclamation through chemical and biological means, rather than strict engineering solutions ([3]).

Which issues were considered most important

For most rice based systems the current economic evaluations suggest that sub-surface drainage including the cost of disposal (management) by (for instance) evaporation areas is not feasible. Theis situation is different where may change if other higher value crops are grown and benefits of watertable and salinity control are greater. It is probable that without sub-surface drainage rice based land use in many parts of the Riverine Plain is not sustainable. This means that salinisation of the landscape will result over time in a significant proportion. To counter such trends a structural change is needed towards the higher value cropping systems. can somehow be included in the rotation. Whilst the full scope of the issues just mentioned was not discussed at the workshop, the opinion was expressed, perhaps intuitively, that However, the workshop felt that research on various aspects of sub-surface drainage should continue in some form nevertheless.

All research issues listed above received about the same score regarding desirability.

Issues 4 and 5 on ground water pumping are also part of the ground water modelling projects (Topic 2).

Natural discharge phenomena to depressions protect land by accepting ground water seepage from recharge areas, for instance there are numerous depressions in the Shepparton region, and Tuckerbill Swamp in the MIA. These areas should not be reclaimed by rice growing else they will loose their ability to provide such benefits by natural processes. The presence of natural discharge areas reduces the need for artificial sub-surface drainage, and therefore affects the design parameters. It is noted that not irrigated dryland areas within irrigation districts serve the same role, and most irrigated areas of for instance the Berriquin District may be sustainable at the expense of the dry land component.

Topic 6: Economics and Optimisation Issues

Mr Ary van der Lely, DLWC, Griffith, gave an overview of key aspects, as shown at Appendix 1. The following list of possible research issues was identified:

1. Develop better economic models of regional salinity impacts and benefits of options
2. Develop data sets for estimating physical effect of LWMP options for a sub-district.
3. Synergies and competition of LWMP options in respect to specific targets.
4. Valuing unpriced benefits in economics analysis
5. Relative risk assessment for options and time frames – consequences for research needs.
6. Farmers responses to increasing soil salinity conditions – social effects.
7. Models to help evaluate benefits of research relative to costs
8. Establishment of targets (or standards) for salinity management

9. Cost sharing for LWMP funding issues

To improve regional economics models (issue 1) it is necessary to improve information re issues 2 to 6, which all input to such a model. It is possible that some issues are partially undo-able, this was most strongly felt in respect to the unpriced environmental benefits. The approach of "standard" setting by either the local or more distant community (or EPA?) was seen as an alternative. Issue 8 reflects this approach. Such standards for significant environmental assets are constraints for should not be exceededland and water management in irrigated areas, which should not be exceeded, no matter what.

It is not certain whether the meeting recognised available analysis tools such as the Multi Criteria Analysis approach, in which environmental off-sets between options are recognised and evaluated after weighting the significance of each (environmental) criteriona. Other criteria (economic and/or social) may be included or excluded for specific evaluations. NSW Treasury accepts Thresshold analysis, where for cases of economic analysis where the BCR is less than unity, the shortfall in Present Value for benefits for an option combination is compared with the assessed environmental benefits which would result if the options was implemented.

The workshop participants mostly did not seem familiar with the topics raised and nothere were no economists were present to provide expert input into the discussion. After discussion they the participants elected issue 5 as being the most worthy of receiving more research effort. In several ways this is already being achieved by sensitivity analysis within economics models, but there are also other aspects, for instance the effect of changing policy scenarios (water reforms), markets, climatic change.

It was also found that tThe economics topic underpinswas seen to be related to most other topics discussed during the day. It is of may have particular relevance for Topics 1/6, 2/7 and 4/4.

Priority Setting between Research Topics

How about presenting the results of the vote in a Table so we can get a better feel for whether any issues stood out.

The above discussion is in respect of priority setting of research issues within Topics. At the end of the day there was also a brief session to discuss whether some main topics deserve more effort than other topicss..

It was recognised that this type of priority setting is potentially very problematic, since the workshop participants group ismay be not necessarily unbiased in terms of representation or views relative to the various topics. This being recognised means thatTherefore the outcome presented below should be treated with caution. Nevertheless it represents an opinion, which may be noted by the CRC for what it isas such..

Priority 1: Spatial Distribution of Salinity Research

The most votes by participants went to Topic 2 - the Spatial Distribution of Salinity topic. Interestingly, thThis includes is the area of ground water modelling which is seen to be important to evaluate the effects of salinity at a smaller or larger landscape scale. It also highlights the need to get better salinity data collection systems, so that agencies have a better idea of the scale of the salinity issue and how it is evolving.

Piority 2: Research into Remedial Measures.

The second most votes went to Topic 5 -the Remedial Measures topic. Surprises me –especially as I don't get the feel from the Topic 5 notes above about any of them being regarded as high priority. This is an interesting outcome, considering the aversion of many land and water management plan area committees to engineering solutions, and the general poor economics of sub-surface drainage systems including evaporation disposal. It is also noted that within Topic 5, no specific issue stood out deserving the most priority. Therefore, the vote is seen as a However it expresses the desire by workshop participants to continue the quest for better sub-surface drainage systems, and the conditions under which these may be applicable.

Priority 3: Research into Management and Practices, and Site Specific Research

The workshop allocated an e equal third priority was allocated to Topic 4 - Management and Practices, and to Topic 1 - Site Specific Research.

Management and Practices are extremely critical to the final outcome in the landscape. In many respects best practices are only tool available to combat salinity in the absence of economically viable alternatives, such as sub-surface drainage. Since a lot is known already regarding this topic, pPerhaps the most attention is needed in improving techniques of extension of existing knowledge. This means that nNot all potential issues identified for potential research in this topic the workshop require a lot of a research priorityattention. The workshop suggested that tThose issues related to rotations and farming systems are the most criticalhave the highest priority.

The priority for research into site specific research may reflect a frustration that despite all the research over many decades there are still issues which are not well enough understood. However, lack of knowledge tend to comes to the fore when trying to put together a modelling framework which integrates all the factors, especially those contributing to salt accumulation or leaching.

Priority of Other Topics

The Off Site Impacts topic and Economics / Optimisation did not get much support from the workshop group. This may reflect the expertise present in the group, which did not include many from these disciplines. Perhaps the workshop group felt this type of research was not a primary responsibility for the CRC. Perhaps these topics do not deserve attention, but the authors of these notes consider this latter possibility unlikely. Government policy in NSW at least is absolutely focussed on ESD, bio-diversity, and health of River systems as a pre-requisite of viable communities, including those that depend on irrigation. The funding of Land and Water Management Plans depends on acceptable economics analysis, just like other major works. There may have been other reasons. Therefore, questions may be asked as to the validity of the priorities set by the workshop participants in this respect.

Models to predict salt loads to The downstream environments exist and are being used already. Further improvements may only occur after completion of research into spatial variation of salinity. As such it may be considered to have less priority. off-site impacts prediction research needs to build on the spatial distribution of salinity in irrigated landscapes. As far as the economics topic is concerned, the comment was made that it really is an overlay for all other topics, and as such it could not be ranked in the manner adopted.

Recommendations

That the Strategic Plan of the CRC be amended to include the various dimensions of salinity research mentioned in this reportwhich exist.

More specifically, the Rice CRC Strategic Plan include a list of the main issues which were identified as being of higher priority during the workshop

The list includes, (in order of priority within each Topic):

Topic 1:

- Issue 6. Effect of varying soil salt concentrations in root zone on plant growth
- Issue 7. Day to day effect of soil salt concentration on production potential.
- Issue 3. Effect soil chemistry and soil structure on water movement

Topic 2:

- Issue 7. Risk based salinity estimation
- Issue 1. Soil salinity monitoring using remote sensing.
- Issue 2. Correlation of EM survey results with soil data

Topic 3:

- Issue 1. Level of salt export likely to occur from each irrigated area.

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Topic 4:

- Issue 4: Effect of farming systems and rotations on salinity
- Issue 3. Develop effective soil treatment options
- Issue 1. Study to improve rice suitability criteria

Topic 5:

- No clear priority between research issues identified. This means all (or none) should be listed.

Topic 6:

- Issue 5. Relative risk assessment for options and time frames.
- Issue 8. Establishment of targets (or standards) for salinity management

It is possible to identify the full scope of topics and issues in the Strategic Plan, with special mention of the above issues, which appear to have priority. Then, when applications for research funds are made, the Management Committee has an overview of the whole range of possible research topics, which facilitates a more informed decision how the proposal fits in, what outcomes should be aimed for and what performance indicators should be applied.

As a final note, a workshop was for one day only, and in many respects this is insufficient for a clear outcome. The workshop did not necessarily represent an unbiased sample of opinion, and the possibility of this is a concern. Ideally, the information compiled herewith should be scrutinised further, and subjected to another workshop session, perhaps consisting of a smaller and more select groupThis is too many issues for the strategic plan to address – we would need to spend all the CRC money on these alone. The plan can list the issues, but we still have to identify our main objectives, actions for achieving them, and performance indicators. We should do this based on the best information we have, which includes the material and opinions presented at the workshop.

Whilst the above list is an indication which may assist the CRC in priority setting, it is recognised that the group attending the workshop did not necessarily represent an unbiased sample of opinion. Such a group would have the task to settle on the priorities for the Strategic Plan, by putting the information of this report in a broader context.It is likely therefore that outside the range of issues identified, other research subjects worthy of support exist. It is recommended therefore that the CRC continues to recognise all research proposals on their merit – so what's the point of a strategic plan?.

Acknowledgements

The Rice CRC would like to thank all participnants at the Salinityb Workshop held in Griffith for their contributions to the Workshop. Special thanks go to Lloyd Kingham, of NSW Agriculture, for facilitating the workshop, and to all those who prepared and presented discussion papers (Wayne Meyer, Shahbaz Khan, Glen Walker, Geoff Beecher, Evan Christen and Ary van der Lely). .Ary van der Lely and Geoff Beecher organised the workshop and drafted the record of the workshop discussions.

TableAppendix 1

List of participants

Name	Agency	Location
Alfred Heuperman	Vic Agriculture	Tatura
Arun Tiwari	CIC	Coleambally
Ary van der Lely	DLWC	Griffith
Derek Poulton	GMW	Tatura
Emmanuel Xevi	CSIRO	Griffith
Evan Christen	CSIRO	Griffith
Geoff Beecher	NSW Agriculture	Yanco
Geoff McLeod	MIL	Deniliquin
Harman Gill	NSW Agric.	Yanco
John Blackwell	CSIRO	Griffith
Laurie Lewin	CRC SRP	Yanco
Lilian Parker	MIL	Griffith
Liz Humphrieeys	CSIRO	Griffith
Lloyd Kingham	NSW Agriculture.	Wagga Wagga
Mahen Mahendra	DLWC	Deniliquin
Peter Fisher	Vic Agriculture	Tatura
Shahbaz Khan	CSIRO	Griffith
Wayne Meyer	CSIRO	Adelaide
Glen Walker	CSIRO	Adelaide

APPENDIX 1

DISCUSSION STARTER NOTES

TOPIC 1: SITE SPECIFIC SALINITY RESEARCH

Wayne S Meyer

All of the issues tabulated by Ary in the schedule below are relevant to the broad topic of salinity and its effects on soils and plants. Within the Rice CRC, it is not possible, nor sensible to address all of these. Rather, we should focus on what we need to know, why we need to know and then how much we know already.

I presume that the focus is on rice, rice agronomic systems and soils and crops within a rice farming system. I presume the questions are directed toward having and preserving a resilient soil and plant system within the Riverine environment. [Resilient means preserving the capacity to recover from perturbation or change.]

Apart from the issues of soil sampling and measurement methods, nearly all others are represented or have been thought about within water, crop and salt balance models. Models formalise what we understand of the processes or the net effects of processes. Given that most of the soil and plant responses we are interested in are dynamic, then the use of models to capture, represent and project our understanding is increasingly important.

However, the models we have are not perfect, complete or evenly balanced in the representation of all processes. SWAGMAN Destiny, for example, tries to capture the most important or driving processes. Yet we know that many of the process representations are first approximations only. It is, therefore, instructive to ask, what are the deficiencies, the uncertainties in this model? This will provide a constructive way of deciding how to structure the search for new understanding and provide a framework into which the understanding can be used.

The key processes where there is uncertainty that I know of are:

· the division of water addition on the ground surface into that which infiltrates, that which runs off and that which is held in ponding store. Currently, we have fairly crude ways of accounting for soil type effects, surface roughness, slope and incoming rate of water addition. The separation is critical in estimating how much water enters the soil profile.

· once water is in the soil, matrix and macropore flow is only guessed at, or not considered at all.

This distinction becomes important when the effectiveness of solute exchange (“leaching efficiency”) is considered.

· currently, we have no functional ways of estimating what changes in soil chemistry and structure will do to water movement. Thus, we cannot yet project how sodicity and salinity change will influence soil hydraulic properties. I see this as an important need.

· currently, most models, including Destiny, consider salt as a conservative solute with no chemical interactions within the soil. In most cases it is also assumed that solutes mix completely in solution. We know this is not the case but we should check that this is not a significant error in the timeframe of our projections.

· unlike a few other models, Destiny does not conceptually assume that the effect of salinity on the plant is an osmotic effect. The evidence that Shalhevet put together was equivocal on this. I have found the concept of the energy required to maintain plant cell integrity a useful one. We know that ion exchange and salt exclusion at the root surface is extremely important. More than 90% of the salt coming to the root surface, even in non-saline conditions, is excluded (Rana Munns knows about this). This has a huge energy requirement. Once in the plant, containing solute ions so that they do not damage cellular function also requires exchange energy. It is the energy cost of maintaining cellular integrity in the presence of high inflows of salt ions which probably has the largest effect on plant survival. In reality though, we do not know for sure what physiological processes, what chemical pathways, are critically interfered with that produce salinity damage and plant death.

· at present, we have a very incomplete understanding of how the plant integrates the effect of having parts of its root system in very different salt solution environments. Within the model construction, we aggregate on a root length by salt concentration basis. Subsequently, feedback is provided so that less root growth will occur in soil layers having high concentrations of salt. There is no direct experimental evidence that supports this logic – indeed it may be impossible to test in real soils. Perhaps it would be possible to set up some extreme situations and test, both experimentally and with the model, whether the logic remains valid. If not, an alternative approach will be needed.

· the way in which we represent how salt in the root zone affects plant function, growth, development and yield is a first approximation. The process currently assigns a salinity stress coefficient on a daily basis using the Maas and Hoffman species response to soil EC. This use of the response function is very different to the original derivation of it. However, there is no other way at present which could be used. Clearly, there is a need to re-examine alternative ways of representing salt effects on different species over their growth cycle.

TOPIC 1: LISTING OF SITE SPECIFIC SALINITY RESEARCH TOPICS

For the following list of topics, the question is: "Do we know enough about this or is this topic a constraint to making progress towards solutions for sustainability".

List of Topics:

Plant- salinity relationships.

- Osmotic effects.
- Plant tolerance (Maas Hoffman etc).
- Plant defences to salinity (accumulate, shedding, expulsion, selective uptake)
- Effect of water salinity (determines feasibility of shandying, etc)
- Effect of soil salinity (soil moisture salinity)
- Effect of soil moisture conditions (determines optimal irrigation practice)
- Effect of weather conditions (ET rate) at various soil salinity levels.
- Interaction waterlogging and salinity
- Specific ion effects

Soil salinity

- Methods by which it is measured
- Spatial variation at the micro scale (as distinct from field scale, which is topic 2)
- Relevance of units (ECe, EC1:2, EC1:5, ECfc)
- Effect of variation within profile on plant growth.
- Sodicity and salinity relationships. SAR, ECe and ESP
- Bicarbonate effects.

- Sodium/Calcium/Magnesium etc.
- Effect on permeability, reversibility of same if EC goes up and down.
- Prediction leaching history from soil salinity profilers (Jury, Rose).

Soil Solute movement

- Effect of pore size distribution
- Specific ion effects on relative transportability
- Leaching theory
- Leaching effectiveness
- Unsaturated flow solute transport.
- Effect of plants and root distribution
- Application of gypsum

Models

- Salt wash off as a function of ECe (Not much known??)
- Leaching and capillary rise functions
- Effect watertable and pressure levels
- Extraction patterns by plants
- DESTINY

There are probably others, which may be added.

TOPIC 2: SPATIAL DISTRIBUTION ISSUES RELATED TO SALINITY

Dr Shahbaz Khan

1. Introduction

Estimating temporal and spatial variability of soil salinity is an important issue in irrigation areas in order to understand complex soil, water, weather and hydrogeological interactions, to evaluate the effectiveness/appropriateness of management practices. This complex task requires spatial and temporal measurements of soil salinity, which may be very expensive and labor intensive. The complexity of the task can be gauged by the fact that many irrigation areas do not carry out regular surveys to obtain temporal and spatial distributions of soil salinity at local, sub-regional or regional scale.

If at least two sets of regional data on temporal and spatial variation of soil salinity are available deterministic soil and groundwater models can be developed to estimate impact of different management options on soil salinity to decide economic merit of these management options. In situations where sufficient soil salinity data is not available risk based spatial salinity assessment models can be used. These model assign individual risk factors to known soil, climatic, topographic and water table data in a GIS environment for regression or composite index based analysis.

This note provides an overview of experimental methods and mathematical models, which can be or has been used in Australia.

2. Measurement of Spatial Soil Salinity Trends

A detailed review and economic analysis of different soil salinity methods is given by Food and Agriculture Organization (FAO, 1999). The soil salinity measurement methods can be broadly classified in three classes:

Soil salinity determination from aqueous electrical conductivity methods

Soil salinity determination from soil-paste

Direct measurement of bulk soil electrical conductivity

The first class of methods are slow and expansive and are not well suited for intensive mapping and monitoring purposes because they require the collection of soil samples and their aqueous extracts. The second class of methods includes collection of soil samples and making saturated soil pastes, however these methods are also labor intensive. Recently spatial distribution of bulk soil salinity is determined using electro-magnetic techniques, which fall under third class. The commonly used instruments for soil bulk electrical conductivity include four electrode (fixed array or mobile) and electro-magnetic induction methods (e.g. EM-38). Most EM devices do not provide variation of soil salinity with depth but depth-weighted bulk soil salinity values. Different researchers have used empirical relationships with succession of EM reading at different depths or vertical and horizontal placement of EM coils to determine distribution of salinity along the soil profile (FAO, 1999).

Recently EM surveys are being carried out in rice growing areas in Australia for a range of purposes such as whole farm planning, rice land suitability and estimation of seepage losses from supply channels. This may provide an opportunity to gather salinity information as well. Generally however, no salinity survey based on the EM techniques has been completed for any NSW district. On the other hand, there have been several surveys of the soil salinity status in individual sub-districts of the Murray valley, the Murrumbidgee and Coleambally irrigation areas based on random sampling.

3. Spatial Simulation of Soil Salinity Processes

i) Deterministic models

Mathematical models, which can simulate three dimensional flow and solute transport in saturated and unsaturated zones e.g. Mike-SHE, fall under this category. Mike-SHE was applied in Wakool Irrigation District in the Murray valley (Storm and Punthakey, 1997) as part of formulating and implementing Land and Water Management Plans. However, because of lack of soil salinity data and communication between the modellers and stakeholders this integrated modelling effort lacked confidence and was not accepted widely.

Other approaches include application of groundwater models with lumped salinity estimates on the basis of recharge and discharge mechanisms e.g.

SWAGSIM (Soil Water and Groundwater SIMulation model) applied in Meadridge Project Area (Prathapar, 1995)

SWAGSIM in conjunction with MIDASS (Model for Irrigation District Accessions, Stream flows and Salt load) applied in Cohuna and Harston (Fordham and Malafant, 1998).

However the sparsity of spatial and temporal distribution of soil salinities renders the future predictions of these studies questionable (Poulton, 1997).

ii) Risk based or stochastic models

Because of the uncertainties involved in the data sets of soil salinities and salinity processes it may be appropriate to utilise a GIS based risk approach which can take into account a number of factors including:

- Groundwater salinity
- Intensity of irrigation & irrigation systems
- Underlying pressure in the deeper aquifer
- Proximity of adjacent areas with high irrigation intensity

- Water quality
- Access to farm and regional drainage
- Proximity to permanent water bodies, water storages and channels
- Water table depth
- Soil type and in particular soil characteristics that determine salt and water dynamics

Different risk factors can be assigned to each of the above parameters to estimate salinity trends under different management scenarios.

4. Current CRC Projects Related to Modelling of Spatial Salinity Trends

Many projects under sub-program 1.4 aim to develop a range of models for simulation of flow and solute transport in soil and groundwater. Relevant projects and researchers are listed below:

- Project 1401 Salt Transport at the Regional Scale
- Peng Xu, Yaping Shao (UNSW) and Charles Demetrious (DLWC)

- Project 1402 Salt Transport at the Farm Scale

- Megan Mclaclan (MSc course work student), Noel Merrick (UTS) and Charles Demetrious (DLWC)

- Project 1403a Quantifying Climatic and Management Impacts on Soil Salinity and Shallow Watertables

- Shahbaz Khan, Evan Christen, Awadhesh Prasad, Fei Zhou, Lousia Best (CSIRO), Asitha Katupitiya and Pei Tillman (CSU)

· Project 1403b Integrated Modelling for Determination of Regional Salinity Trends in Irrigation Areas

PhD student, CSU, Shahbaz Khan (CSIRO), Asitha Katupitiya, and Pei Tillman (CSU)

An outline of this project is appended for discussions and aligning its objectives to the outcomes of this workshop.

5. Possible Research Directions

Considering the range of current mathematical modelling projects in CRC it is imperative to support these model developments with salinity monitoring data on a regional scale. Some possible research areas in spatial salinity assessment are given below:

i. Salinity measurements using remote sensing techniques

ii. Correlation of EM surveys with other soil sampling data

iii. Impacts of conjunctive water use on spatial soil salinities

iv. Soil salinity monitoring on a monthly/seasonal basis in a range of crop, water and watertable conditions in an irrigation area with watertables less than 2 m from surface

v. Soil salinity monitoring on daily basis in conjunction with some of the paddock water monitoring projects

These monitoring studies will help improve the understanding of salt accumulation and leaching mechanisms on a local and regional scale and to refine mathematical models.

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TOPIC 3: OFF SITE SALINITY EFFECTS

Dr Glen Walker

In this paper I will focus on salinity as the only off-site impact, although noting that there may be trade-offs in minimising salinity impacts with other adverse impacts e.g. nutrient export.

Within the Murray-Darling Basin, the export of salt from irrigation areas is constrained by the Salinity and Drainage Strategy. The key performance indicator for this Strategy is the salinity at Morgan, one of the key off-takes for Adelaide’s water supply. The importance of the salinity at Morgan is not so much a reflection of the fragility of the Murray as a water supply, but the fragility of much of the other water resources in SA (Jolly et al., in prep). Recent publicity associated with the Salinity Audit has used the NHMRC/ARMCANZ Australian Drinking Water Guidelines of TDS of 500 mg/L (833EC). The WHO (1984) guideline is 1000 mg/L. The basis of these guidelines is not health, but palability. Bruvold and Daniels (1990) ranks the quality of drinking water as excellent for TDS < 80, Good 80 – 500, fair 500 – 800, poor 800 – 1000 and unacceptable if TDS > 1000. The flow-weighted mean salinities of most streams in SA exceed 500 mg/L as does many of the groundwater supplies. There is the possibility of 2 reservoirs being decommissioned because of salinity impacts. Also, the Mallee region groundwater supply will gradually degrade over the next 50 years. What stops this being a disaster is the constancy of the River Murray supply as well as the development of cheaper desalination options. The River Murray is generally used during the drier periods when its salinity is higher. There is the possibility of pumping during higher flow and using the storages to minimise salinity impacts, but this is not done.

The other impacts, including those on irrigated agriculture downstream have been summarised recently in the GHD review of cost functions for the Salinity and Drainage Strategy. The areas that impact mostly on Morgan are of course, those areas near Morgan, with half of the expected increases in salinity occurring from the Mallee region.

For both irrigated and dryland areas, there are alternatives to minimising salt exports, including salt interception schemes, desalination plants, pipelines etc. It is the public perception of the River Murray that prevents these being implemented more widely. If the River Murray is degrading, it is an indicator of a degradation of the Murray-Darling Basin as a whole. Engineering options will need to be implemented more widely, but in parallel with more efficient practices and sustainable agriculture as well as changed social attitudes to acceptable degradation.

How do most of our irrigation areas fare with respect to salinity exports? The recent study of Jolly et al. (1997) on salt balances in the MDB does not isolate irrgation areas, but it does indicate that for the Victorian irrigation areas, more than 3 times the input salt is exported. On the other hand, NSW irrigation areas, such as the MIA are nett importers of salt. Without a familiarity of these areas, it is not clear to me whether this is due to groundwater still rising in these areas, export of salt to areas such as Barren Box Swamp or the lack of connection between the high water tables and stream network. Over the next 40 or 50 years, will the MIA be exporting 4 times as much salt as it does now?

Do we have the tools to estimate salt export from various sub-catchments in our irrigation areas and how these may change in future with or without changes in land and water management. I gather that the MIA uses a simple method to estimate salt exports based on salt concentration in the surface soils, together with drainage fluxes. In some cases, complex models such as MIKE-SHE has been used. Studies on measuring and modelling the processes include Nathan et al. (1992), Ayars and Meek (1994), Ayars et al. (1997), Mudgway et al. (1997), Nathan and Mudgway (1997), Jayatilaka et al. (1998), Gilfedder et al. (1999), Connel et al. (1999). The processes related to salt export vary from being mainly wash-off from irrigation bays to direct connection to drains. It is clear that while complex models, such as MIKE-SHE or Connel et al. (1999) can be useful in analysing situations, the ability to obtain parameters in heterogeneous areas such as the Riverine Plains is limited.

There is a limited flexibility with respect to changing land and water management practices to minimise salt export. If we have irrigation, we produce drainage water and develop high water tables. The alternative to salt export is to store drainage water in disposal basins. These can either be large disposal basins external to the irrigation areas or on-farm or community basins in the irrigation areas. A recent project on disposal basins has found that most of the irrigation areas are unsuitable for on-farm basins, if we are to minimise adverse environmental impacts. It is also not clear whether there is sufficient appropriate land for community basins if we were to store all the drainage water in the irrigation areas. It is likely that significant fraction of the drainage water will need to be exported either in-stream or to regional disposal basins. Disposal basins need to be considered in conjunction with water re-use schemes, plantations and serial biological concentration schemes.

There are many other off-site effects associated with salinity and high water tables. These include impact on wetlands and important environmentally sensitive areas due to shallow water tables, increased flooding and salt wash-off ; formation of anoxic saline zones at bottom of streams due to rising water tables in adjacent areas, bank-slumping due to high water tables, flocculation or dispersion of surface clays, formation of reducing zones in waterlogged areas, with possible export of unwanted solutes; and even reduction of turbidity due to groundwater inflow.

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TOPIC 4: PRACTICES AND MANAGEMENT

Geoff Beecher, NSW Agriculture

Rice CRC

Program 1:Sustainability of Natural Resources in Rice Based Cropping Systems

Salinity Workshop, CSIRO Griffith

November 25, 1999

Section 4: Management and Practices

What has happened in the past?

High levels of access to high quality water

Lack of concern about the level of or efficiency of useage

Rising water tables due to episodic rainfall events and irrigation

Irrigation Areas and Districts that lacked external drainage access

Salinity problems not arising from water quality, therefore need to look towards soil drainage and reclamation programs

What may/will happen into the future?

Decreasing access to water- COAG, MDBC Cap, NSW Water reforms - Environmental flows

Increased competition , reduced access to of allocation will lead increasingly to growers retaining water on farm for recycling

Increased exploitation of groundwater resource along with increasing salinity of incoming surface irrigation water.

Use of high and low quality water shandying water due to restrictions on water quality acceptable into community drainage systems.

Approaches

Minimize accessions to groundwater system

Watertable control through drainage

Saline agriculture

Saline groundwater disposal

Solve by reducing inputs???

- On farm In field practices

Land/soil selection – 1

Whole farm planning – 2

Irrigation methods – 3

Irrigation scheduling – 4

Soil treatments / modifications – 5

Land/soil selection – 1

Rice soil suitability criteria

EM-31 targeted sampling

sodicity assessment

Rice field water use limit

Whole farm planning – 2

Irrigation design

Match supply flow with bay widths and field length

Reduce application times to say 4-6 hours leading to increased application efficiency

Research on soil infiltration characteristics, flow rates and field length

Irrigation methods – 3

System design and maintenance

pressurised vs surface methodologies

terracing, border check, bank-less channels

Irrigation scheduling – 4

Neutron probes

Tensiometers

Gophers, Diviners

Enviroscans

Weather based technologies eg Waterwatch, evaporimeters

Soil treatments / modifications – 5

Puddling

Compaction

high impact compaction

WT control through drainage

Off farm drainage of high EC water- NO

Tile drains / Mole drains / Tube wells

drainage recycling

water quality

Solve by reducing inputs??? Off farm

Dry land agriculture outside/upstream from irrigated regions

Installation of surface drainage systems

DLWC / IC channel systems??

Identified gw accession points

Solve by dealing with the consequences? - On farm

Management of saline land – 1

Sub surface drainage – 2

Changed farming systems / rotations – 3

planting practices

tillage

minimum tillage

Management of saline land - 1

- Use of saline water
- Crop salinity tolerance/ crop selection
- Biological serial concentration
- Role of trees
- Role of Saltbush
- Accept lower levels of production???
- Abandonment

Sub Surface Drainage - 2

- Tile drains
- Mole drains
- Spear points/tube wells
- Evaporation basins

Solve by dealing with the consequences? - Off farm

- Spear points/tube wells
- Increases in water supply/drainage salinity

Quotes

It is not known beyond speculated assessments - what the areal extent of salt affected soil is?

To what degree agricultural productivity is being reduced by salinity

Whether the trend in soil salinity development is increasing or decreasing

Suitable sub regional / regional scale inventories of soil salinity do not exist

Practical techniques to monitor salinity do not exist

Practical techniques to assess the impact of changes in management upon soil salinity and salt loading at a regional scale

TOPIC 5: REMEDIAL MEASURES

Evan Christen – CSIRO Land and Water, Griffith

Introduction

In saline lands remedial or management measures range from land retirement, to agronomic practices in choice of crop and land management to engineering intervention through subsurface drainage of one type or another. The choice of measure in general terms depends upon the value of the land the cost of the management technique and the cost of disposal of saline drainage where necessary.

Land retirement

In the Tragowel plains this has been adopted extensively for class 3 and 4 lands. These lands are fenced off and no longer irrigated or grazed, salt tolerant vegetation is allowed to grow and improve the aesthetics of the land. In this scenario the irrigation water is concentrated on the better, normally more elevated, class 1 and 2 land. Presumably the class 3 and 4 land then acts as the discharge zone and an equilibrium is reached between this and the recharge on the class 1 and 2 land.

Problems/questions arising:

1. some highly salinised lands which may impact unfavourably on water quality in drains and creeks.

2. water concentrated on smaller area – hydraulic loading increased

3. will the salinised areas provide adequate discharge or will the areas grow – 15-25% of MIA (van der Lely)

4. water trading away from the area, affecting overall viability

Agronomic controls

The main agronomic option for salinised land in the irrigation areas of the Riverina is to grow rice. This is because rice promotes a downward movement of water and thus leaching and rice is relatively salt tolerant. Work by Beecher has shown that there is little yield reduction in irrigating rice with water of up to 4dS/m, however this was on a “leaky” site with rice water use about 18 - 22 Ml/ha. Recent trials in the Tragowel plains have successfully grown rice on soil with salinity of up to 10dS/m using fresh irrigation water. Growing rice on saline lands in rotation with pasture as shown by some Benerembah farmers can apparently be sustained for decades as the salt is pushed down by the rice crop and then the soil gradually resalinises.

Problems/questions arising:

1. Is the salt merely pushed to the margins causing problems elsewhere

2. Is there enhanced discharge to drains and creeks

3. A one crop solution

Engineering options

Introduction

Sub-surface drainage systems are used to reclaim saline and waterlogged lands and in the long-term to maintain a favourable salt and water balance in the root zone. Sub-surface drainage ranges from open drains to horizontal pipe drains to vertical drains. Open drains and horizontal pipe drains are likely to discharge saline water with limited reuse potential whereas vertical drains in the form of tubewells may discharge fresher water suitable for conjunctive use with surface supplies.

In considering any of these options the greatest constraint is the disposal of saline drainage water. It is no longer possible to dispose of large volumes of saline water into surface watercourses as this has adverse impacts upon downstream users and the aquatic environment. Thus when considering remedial measures the drainage system and disposal/treatment/reuse mechanism must be considered in tandem.

Minimising salt loads from drainage systems

In order to minimise the difficulty of disposal, where possible sub-surface drainage needs to be designed and managed to a) minimise the drainage volume to that required to maintain rootzone salinity, b) minimise the drainage water salinity. In design terms this requires the placement of drains in the least saline soil layers, or with tubewells placement in low salinity aquifers. In terms of general siting to carefully consider the regional geohydrology in terms of possible regional inflows to the drained area which will increase the drainage volume without directly benefiting the root zone. In management terms firstly good irrigation practice is required to limit the drainage volume and secondly management of the drainage system – controlled drainage is required. Controlled drainage restricts the discharge from a sub-surface drain outlet resulting in a higher field watertable. The watertable drops naturally over time due to evaporation and deep seepage. Controlled drainage is useful in that it restricts direct loss of irrigation water by bypass flow to the drainage system and it limits the impact of regional piezometric levels and hence inflows by not creating too great a drawdown. Recent work by Christen and also Hoogers in the MIA and Ayars in California have found controlled drainage to be effective in reducing salt loads from drainage systems and also irrigation water requirement. There is a requirement to expand this research to determining the optimal drain watertable management depth for different crops with different watertable salinities and also irrigation scheduling practice that promotes use of the shallow watertable. When an on-farm evaporation basin is used to dispose of drainage water then this adds a further level of complexity in optimising the drainage system management. A tool for doing this is urgently required in order to properly use existing evaporation basins in the MIA and have a sound management tool available for farmers developing new basins.

In terms of drainage design many workers have shown that shallower closer spaced sub-surface drains result in lower drainage water salinity. In the MIA both Christen and Muirhead have shown this to be true using mole drains. However, mole drainage is not ideally suited to the farming system, shallow pipe drains would be, however the costs are considerably higher. There is a requirement to continue research into improved low cost shallow horizontal drainage systems.

Groundwater pumping

Groundwater pumping in the irrigation areas of NSW in the Riverine plain has generally been from the deeper aquifers for irrigation water supply purposes. This pumping has some benefit in managing watertables and rootzone salinity but its' effectiveness is generally regarded to be limited. Pumping of shallower aquifers (<20m deep) which are generally discontinuous prior stream formations has not been widely adopted because the shallow groundwater quality is generally poor. Where this is the case then water reuse is limited and disposal is required, the prime example of this is the Wakool-Tulakool groundwater pumping/evaporation basin system. Conjunctive use of groundwater with surface water has been extensively practiced in the Shepparton region for groundwaters up to 3.6dS/m. Groundwater above 3.6dS/m is still pumped but is disposed of either into the drainage system (Salt credits) disposal basins or the supply system (distributed conjunctive use). This has been useful in reducing root zone salinities and increasing water available for irrigation. Adoption by farmers has been widespread and the emphasis in recent times has changed from groundwater as a supply to pumping for salinity control.

However, there have been difficulties in the implementation relating to the biophysical system, planning and institutional arrangements. The physical problems relate to determining suitable cost effective farm investigations to locate groundwater pumps and determine an appropriate level of pumping. Specific problems that have arisen are rapid salinisation of small aquifers and interference between pumps. In the conjunctive use of water the main problem has been farmers not mixing with adequate volumes of surface water and thus applying water at unsafe salinities. In general terms the planing for shallow groundwater planning is problematic as the location of suitable aquifers is unknown and likely to be poorly distributed, also a good understanding of the system is required if saline drainage water is to be added to supply water. In terms of institutional arrangements the greatest difficulty will be the division of authority of surface water and groundwater between the irrigation companies and the Department of Land and Water Conservation. This will lead to poor integration of salinity and drainage strategies and data fragmentation.

There is a need for a comprehensive and co-ordinated research program into these issues in relation to the pumping of shallow groundwater for salinity control. This work can incorporate the CSIRO/Coleambally Irrigation project on conjunctive water use and NSW Ag work on groundwater quality and using the existing Rice CRC groundwater projects. Essential research to compliment this is required regarding disposal and reuse options at a farm, community and regional scale.

TOPIC 6 : OPTIMISATION AND ECONOMICS RESEARCH

Ary van der Lely, DLWC, Griffith

Discussion Starters:

A lot of economic analysis principles exist, and most of these work. Their failing lies with the physical data supplied to the economics models, and the simplification of assumptions, which essentially try to predict human behaviour in changing, worsening scenarios.

Yield versus Salinity.

Productivity decline versus salinity has been established for most crops. The effect on farm viability depends on the possibility to vary inputs, to switch to other crops, to abandon the land.

Often, economics models use averages for salinity of an area, ignoring the large variation that exists from field to field, or within fields. For instance, with an average salinity of 2dS/m it is possible that 10% of the land has salinity above 4 dS/m. The MIA LWMP economics analysis has suffered from this simplification.

Counter Measures

Where land is not scarce, higher value crops may be grown on the remaining good land, reducing financial and economic impacts. This principle for the MIA and CIA LWMPs have treated the MIA and CIA as one large farm in which various resources may be reallocated, within constraints.

Where land is scarce sub-surface drainage of other crops may be considered. Recent work includes consideration of off-site impacts or the costs of disposal of salts.

Unpriced Benefits

Methods to evaluate unpriced benefits of options are still poor. Multi-Criteria Analysis is a subjective process, dependent of the weighting of the criteria used and bias of the assessors. For downstream areas, the Murray River and intra-irrigation areas, the cost of salt loads and salinity to agriculture and urban supplies has been captured, but the cost of salinity to eco-systems is not quantified well at all. The same applies to land lost to production, and which now also has a reduced environmental value.

Competition for Benefits between LWMP Options.

Different options may be targeted towards the same objective, eg a reduction in accessions. In many cases the effect of several options is not additive, there is an overlap. To economists the possibility of double counting benefits is always treated seriously. This problem may be overcome by applying all options to a recharge / discharge model, from which the ground water level effect and salinity hazard may be evaluated.

For surface salinity issues, the effect of salinity reductions should be evaluated using surface hydrology models. In some instances simple water and salt balance may suffice.

Whilst this is understood, the models to evaluate the combined effect are imperfect.

Optimisation

LWMPs have a number of objectives, which can be translated into targets. The MIA plan has seven quantifiable target areas (profitability, economics, accessions/land salinity, drainage water salinity, water quality, surface and sub-surface drainage volumes). Each option contributes to one or more target areas, sometimes negatively. The rate of adoption of each of about 80 options was optimised to achieve all targets at ones. This process depended very much on the quantification of the individual contributions. Despite considerable research existing this remains mostly guesswork where the values apply to a regional scale, including its full range of soils, crops, topography and hydro-geological conditions.

Economics Models

Economics models depend on the physical parameter inputs, which are often derived from other models. Errors multiply. Data are expensive. The quality of its presentation is improving all the time (GIS, colour printers), but its inherent quality is becoming more difficult to trace.

The need of economists in terms of input to their models should be recognised early in projects, not after when the scientists are finished with their work.

The assessment of salinity costs and benefits remains contentious. Initially the MDBC used a drainage evaluation model (DEM) to evaluate costs proportionally to the percentage of land affected. Shepparton benefited from that approach. Subsequently specific higher value crops were kept separate, because it was recognised these crops would suffer less, because they would be grown on the best soils of a property (Berriquin LWMP). For the MIA the process went a step further and all crops were optimised in a linear programming technique developed by Jones and Marshall. Its results in its final evaluation ignored intra-paddock variation. It also was assumed that farmers will adjust their practices and paddock layouts frequently after they first notice salinity symptoms in their field.

The problem of these models is with the input data, but also the assumptions used when assessing behaviour following the onset of a salinity problem.

Cost Sharing

The MDBC has produced a discussion paper on cost sharing, emanating principles such as polluter pays, user pays, beneficiary pays, and beneficiary compensates. Whilst there is a lot of discussion on these principles, in actual fact most negotiations for LWMP is based on simple horse trading, with the use of some jargon in the process. Quantification of most components of costs and benefits is not of sufficient accuracy to go much beyond that. Nevertheless, it provides a basis for these negotiations, and probably boundaries for the positions each party takes.

Risk Analysis

LWMPs are implemented for periods up to 30 years. Over this periods many of the assumptions made are shaky. Risk Analysis should include the effect of markets, trends in the landscape, crops, practices, variation in adoption rates, policy reforms. For some effect there sometimes is an estimate (eg ground water trends, soil salinity trends), but most end up in the too hard basket.

Each option should be evaluated for risk. For some the value of the BCR relative to costs is used as an indicator as to whether an option is risky or not. In other cases other parameters are used, eg the degree by which a specific option is likely to be adopted. The potential error of the estimates for benefits and costs are other factors. The need for structural adjustment may loom large in the background.

The implementation of NSW Water Reforms at the end of the MIA LWMP planning process is a classic.

RESEARCH IMPLICATIONS

1. The improvement of economics evaluation is dependent on the improvement of integrating land and water model outputs. There is a great need to get better physical data, eg, the effect of options. The physical models, which integrate individual options, require improvement.

2. The matter of unpriced benefits deserves more attention. The methods available do not appear to produce reliable results.

3. The models used to date to evaluate integrated salinity in LWMP planning areas need to be reviewed and the assumptions challenged.

4. The stochastic nature of salinity in field situations needs to be recognised more, and become part of economic assessments.

5. The likely behaviour of farmers, when confronted with salinity, needs to be better defined and then converted into assumptions, which are more useful for modelling purposes.

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[1] Recent results of research for dryland salinity areas do not support EM technology, whilst radio-metrics methods are subject to error due to the complexity of interpretation of the signals.

[2] The low cost statistical distribution survey mentioned in the text will indicate whether or not a significant proportion of land for a land use in a sub-district has a high salinity. If there is not, more intensive mapping is not required. If there is, then it is likely that local knowledge, EM surveys for whole farm planning, and feedback from farmers will provide the knowledge of where the problems occur.

[3] The authors note in respect of chemical controls that research on gypsum has occupied researchers for at least 50 years. How much more is needed? Is this mostly a matter for implementation? Can significant progress towards sustainability be made by this avenue?